Government of **Western Australia**
Department of **Mines and Petroleum**

PROSPECTIVITY OF STATE ACREAGE RELEASE AREAS L09-3 and L09-4, WAIGEN AND LENNIS AREAS, OFFICER BASIN

Geological Survey of
Western Australia

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Introduction

Acreage Release Areas L09–3 and L09–4 lie in the central part of the Officer Basin adjacent to the northern basin margin, and Area L09–4 abuts the South Australian border. Area L09–3 spans latitudes 26°24'55"S and 27°29'55"S, and longitudes 127°05'E to 128°E, and has an area of 10 922 km^2. L09–4 spans latitudes 26°24'55"S and 27°29'55"S, and longitudes 128°0'E to 129°0'E, and has an area of 11 910 km^2. The Officer Basin is a large intracratonic basin that extends from the eastern flanks of the Pilbara and Yilgarn Cratons to the central west of South Australia and occupies an area of about 525 000 km^2, with about 300 000 km^2 in Western Australia (Fig. 1). The basin overlies older Proterozoic and Archean sedimentary, igneous, and metamorphic rocks. As recognized in Western Australia (hereafter referred to as the western Officer Basin), the fill is Neoproterozoic to Cambrian (ca. 830 to 500 Ma; Fig. 2). Late Cambrian volcanic rocks and younger rocks are placed in the Gunbarrel Basin, which obscures much of the Officer Basin in Western Australia. These are included in the Officer Basin in South Australia.

The Officer Basin is underexplored, due to the remote location and its age and lack of exposure. Thin, but good-quality source rocks, and sandstones with excellent reservoir characteristics, have been identified within the succession (Ghori, 1998; Carlsen et al., 2003). Seals include salt, shale, and diamictite. Potential traps formed from the mid-Neoproterozoic to the Paleozoic. The timing of hydrocarbon generation is poorly constrained.

The Goldfields Gas Transmission Pipeline runs south from the North West Shelf to Kambalda, about 200 km west of the Officer Basin, and then terminates at Esperance. Potential markets or delivery points for discoveries include mining centres along this pipeline, Alice Springs in central Australia, and coastal ports. A well-maintained gravel road links Warburton to communities in South Australia and the Northern Territory, and a few four-wheel drive tracks traverse the acreage release areas.

Regional geology and stratigraphy

The western Officer Basin has a sedimentary fill of up to 8 km of mixed carbonate, silty and sandy siliciclastic, and evaporitic rocks (Fig. 2) deposited mostly in shallow-marine to coastal, and locally continental, settings (Grey et al., 2005). The succession shows marked similarities to other Neoproterozoic basins in central Australia. The structure of the basin has been largely influenced by major salt sequences (except in the northwestern Officer Basin), which have mobilized during several tectonic episodes that punctuated deposition. Four distinct structural zones are present in the main part of the basin in Western Australia: a marginal overthrusted zone along the northeastern margin of the basin, an adjoining salt-ruptured zone, a central thrusted zone, and a western platform (Simeonova and Iasky, 2005).

The acreage release area lies to the south of, and includes parts of, the Mesoproterozoic Musgrave Complex (Fig. 3), within the northern part of the Waigen area and the northeast part of the Lennis area. A thin Phanerozoic succession (Gunbarrel Basin) overlies the Officer Basin in the central and southern parts of the release area. Within Area L09–4 there is one deep stratigraphic drillhole and a small number of shallow water bores. There is a part of seismic lines LN66–067A in Area L09–3.

GSWA Vines 1 was drilled in 1999 to a total depth of 2017.5 m to investigate the stratigraphy and petroleum source potential of strata in the Waigen area. The hole was located to the south of outcrops of the Buldya Group (Supersequence 1) and to the north of outcrops of the Cambrian Table Hill Volcanics. This stratigraphic hole was diamond cored from 44.5 m to total depth, and thus provides excellent geological control. Vines 1 was originally interpreted by Apak et al. (2002) and Stevens et al. (2002) as intersecting a section of earliest Cambrian age (the Vines Formation), unique in the Officer Basin. Haines et al. (2008) reassessed the succession and concluded that a section spanning Supersequences 2 to 4, and possibly the top of Supersequence 1, was present (Fig. 4). This includes fluvial conglomerates

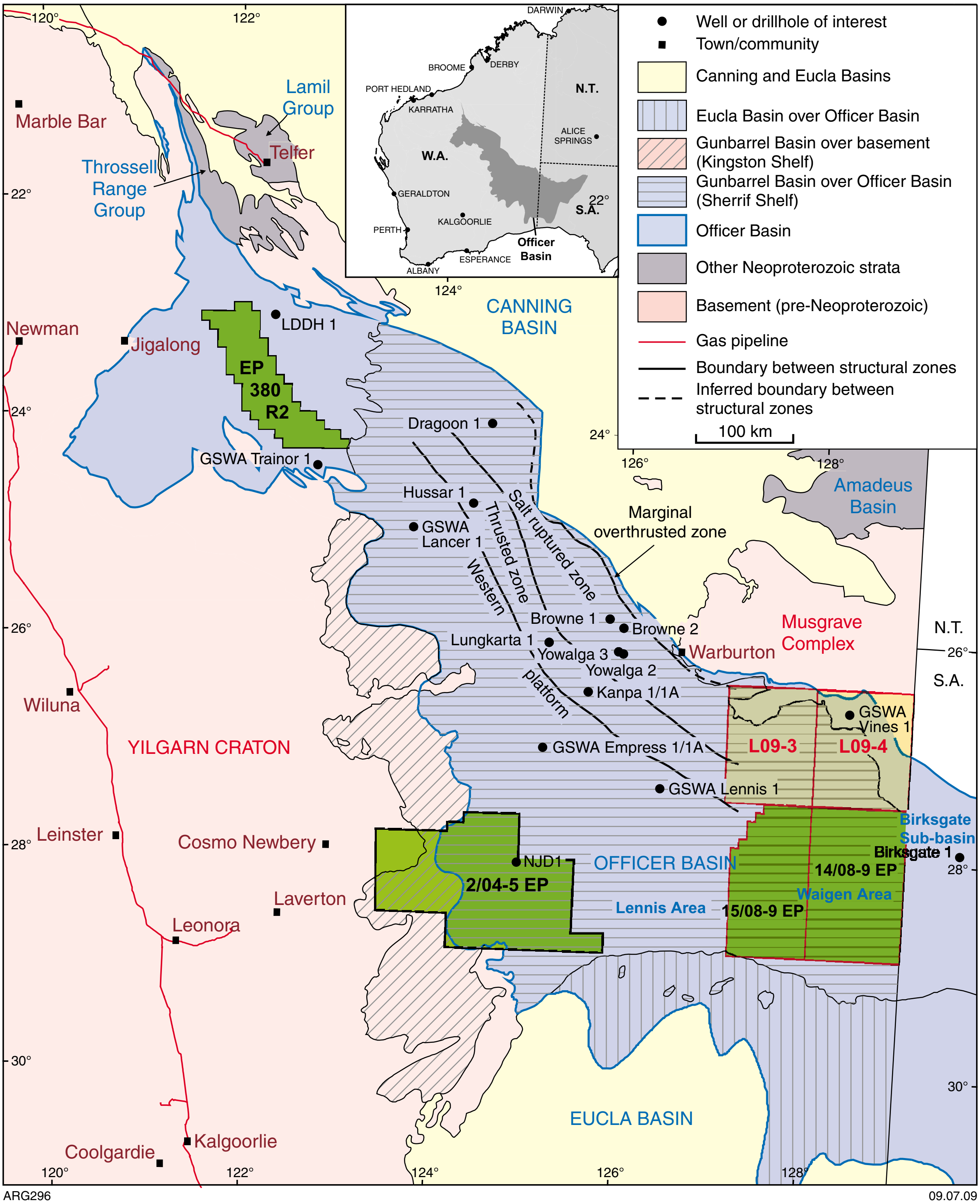

Figure 1. Regional setting and subdivisions of the western Officer Basin, largely after Simeonova and lasky (2005) and Grey et al. (2005).

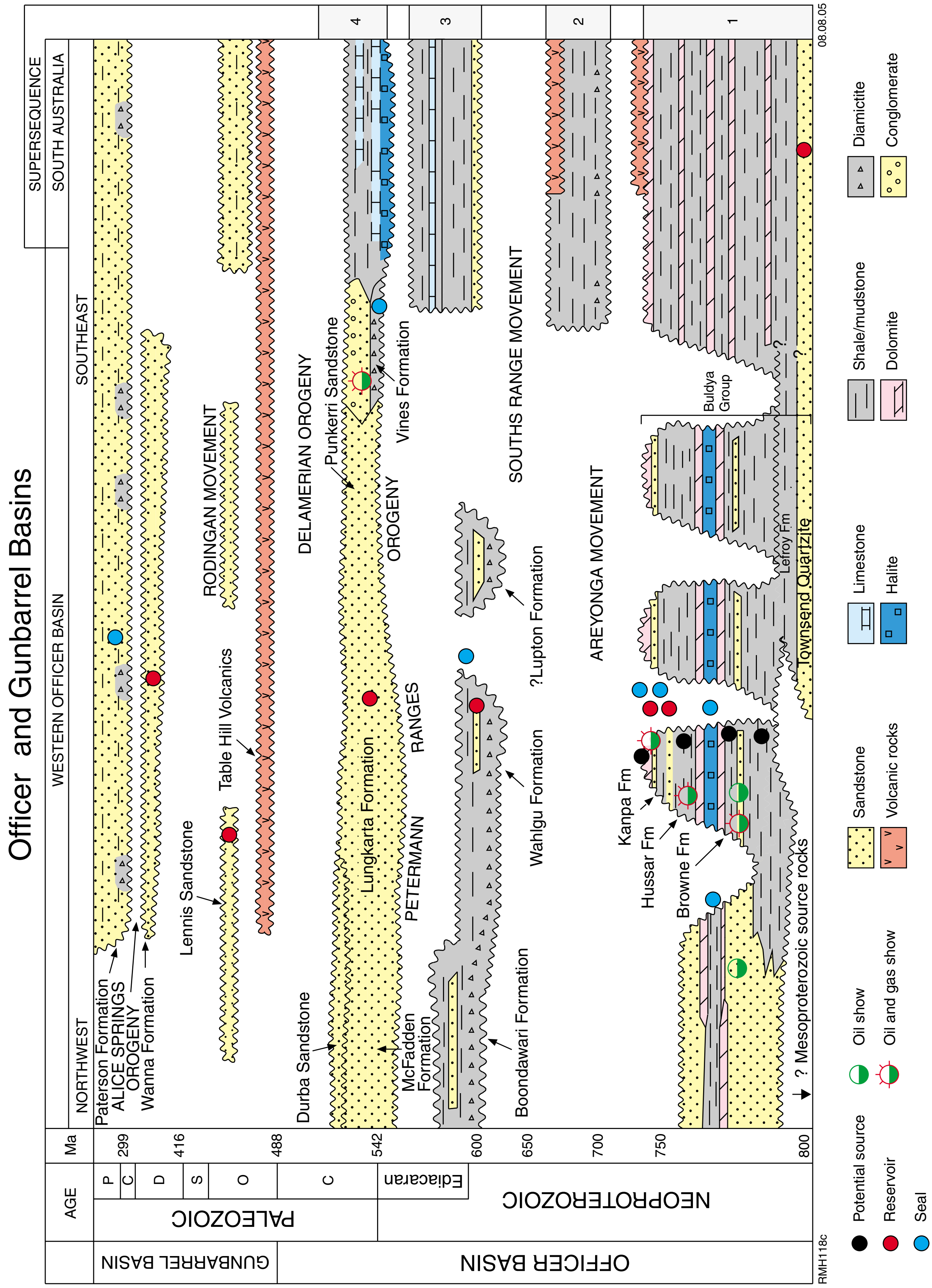

Figure 2. Stratigraphy and petroleum systems of the Officer Basin.

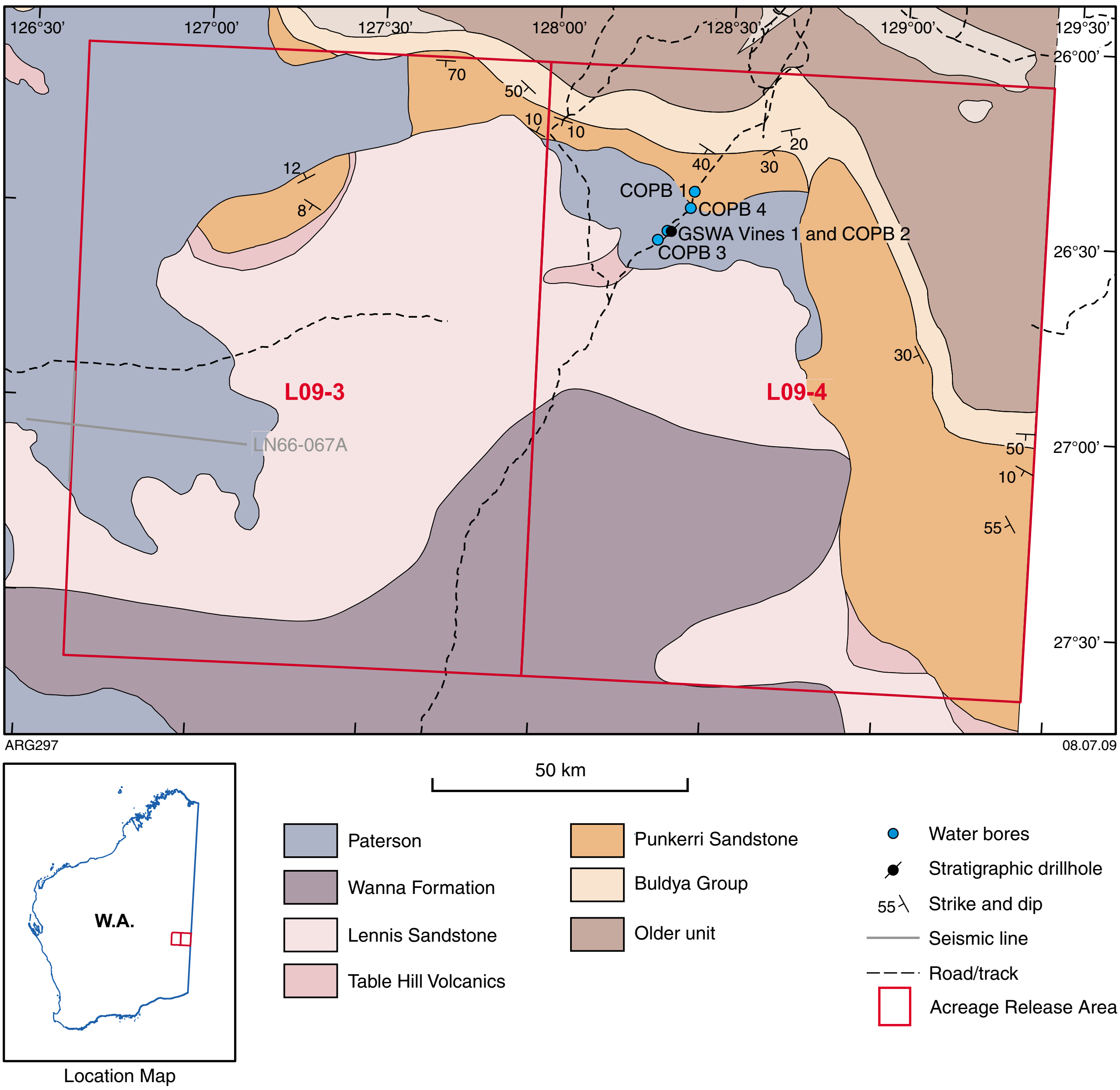

Figure 3. Simplified geological map of acreage release area L09–3 and L09–4.

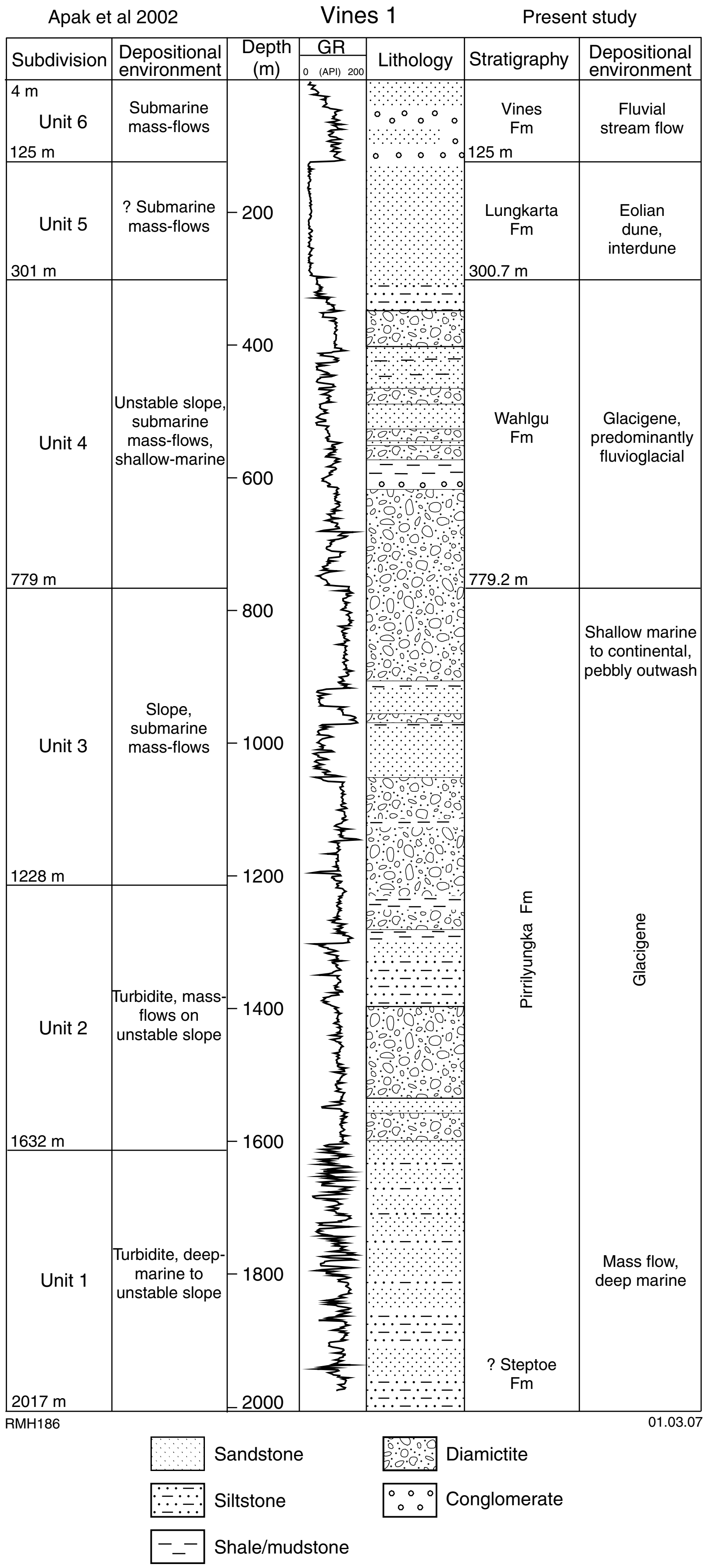

Figure 4. Previous and present stratigraphic and facies interpretations of Vines 1 (after Haines et al., 2008).

(Vines Formation, Supersequence 4, ?Neoproterozoic–Cambrian cusp), eolian sandstones (Lungkarta Formation, Supersequence 4, ?latest Neoproterozoic), and glacigene deposits (Wahlgu Formation, Supersequence 3, and Pirrilyunka Formation, Supersequence 2). The base of the hold may be in the Steptoe Formation of the Baldya Group.

Petroleum prospectivity

The petroleum potential of the Western Australian Officer Basin was discussed by Perincek (1998), Carlsen et al. (1999, 2003), Ghori (1998, 2002), and Simeonova and Iasky (2005), with the South Australian part reviewed by Morton and Drexel (1997), and Boult and Rankin (2004). Hydrocarbon shows have been recorded throughout the western Officer Basin including Vines 1, NJD 1, Kanpa 1A, Browne 1, Browne 2, Dragoon 1, Hussar 1, Mundadjini 1, Boondawari 1, and LDDH 1, and in the Mesoproterozoic–Paleoproterozoic (c. 1600 Ma) Scorpion Group in mineral hole OD 23, in the eastern Capricorn Orogen. Exploration drilling of Neoproterozoic–Cambrian rocks in the Amadeus Basin in the Northern Territory and in the Officer Basin in South Australia has led to several oil and gas shows, and the discovery of the Dingo gasfield in the Northern Territory.

Results to date have identified reservoirs with porosities greater than 20% and permeabilities ranging from hundreds of millidarcies to more than a darcy, particularly in the Hussar Formation (c. 780–800 Ma). Halite beds greater than 10 m thick in the Browne Formation (800–820 Ma) and shales greater than 10 m thick in the Browne, Hussar, Kanpa (?820–720 Ma), Wahlgu Formations (?600 Ma), and Vines Formation (?540 Ma) provide potentially effective seals. Thin, but good-quality source rocks have been identified within the Browne, Kanpa, and Hussar Formations. The close association of laminae-scale source rocks with good quality reservoir and seal horizons indicate the basic physical elements of a petroleum system. The widespread, though minor, shows indicate that hydrocarbons have moved through the system. Maturity modelling suggests that substantial hydrocarbon traps had formed before most of the potential source rocks in the Officer Basin first entered the oil window, and much of the section remains in the oil-maturation window today (Ghori, 1998, 2002). Mesoproterozoic strata that underlie the Officer Basin are also considered potential source rocks (Ghori, 1998; Hocking, 2002).

Data available to assess the petroleum potential of L09–3 and 4 include drillhole Vines 1, parts of seismic lines LN66–67a and LN66–69a (from the 1966 Lennis North Seismic Survey), regional aeromagnetic and gravity data, and the Waigen gravity survey (3 × 2 km grid; Blundell, 1999). The petroleum potential of the Waigen area was reviewed by D'Ercole et al. (2005), and the Lennis area by Apak and Moors, (2001). Simeonova and Iasky (2005) interpreted seismic data from the Officer Basin including the Lennis area.

A mud-gas show in Vines 1 of a maximum 1009 units (a 30-fold increase in background) was observed in the hot-wire total-gas detector at 1482.9 m, from fractured and veined mudstones. It is assumed that the show was sourced from an open fracture in the subsurface as a trace of gas could be heard escaping from the core, but the core around this depth had no visible porosity (Apak et al., 2002). Hamilton et al. (2004) investigated fluid inclusions in veins associated with the gas show but observed no oil. The fluid inclusions could be explained by the mixing of high temperature and low salinity water (approximately 155°C, 35‰) with low temperature high salinity water (approximately 60°C, 180‰), with the most likely source of brines being evaporites from the Browne Formation of the Buldya Group. They also found probable bitumen in pore spaces in sandstone at six intervals between 125.2 and 285.3 m (Fig. 5), indicating the prior presence of oil in

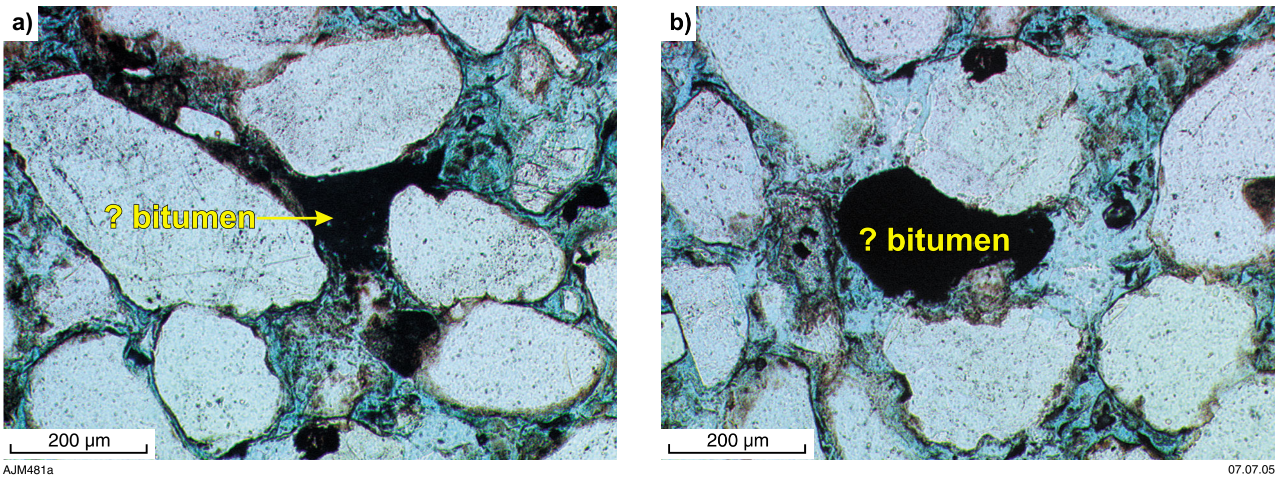

Figure 5. Photomicrographs of Vines 1 sandstone samples used for GOI (framework grains containing oil inclusions) and other petrographic analyses: a) Top of unit 5 (125.2 m) — medium- to coarse-grained, friable bleached sandstone. The arrow points to opaque amorphous material, possibly bitumen; b) Unit 5 (126.8 m) — opaque material possibly bitumen (after Hamilton et al., 2004).

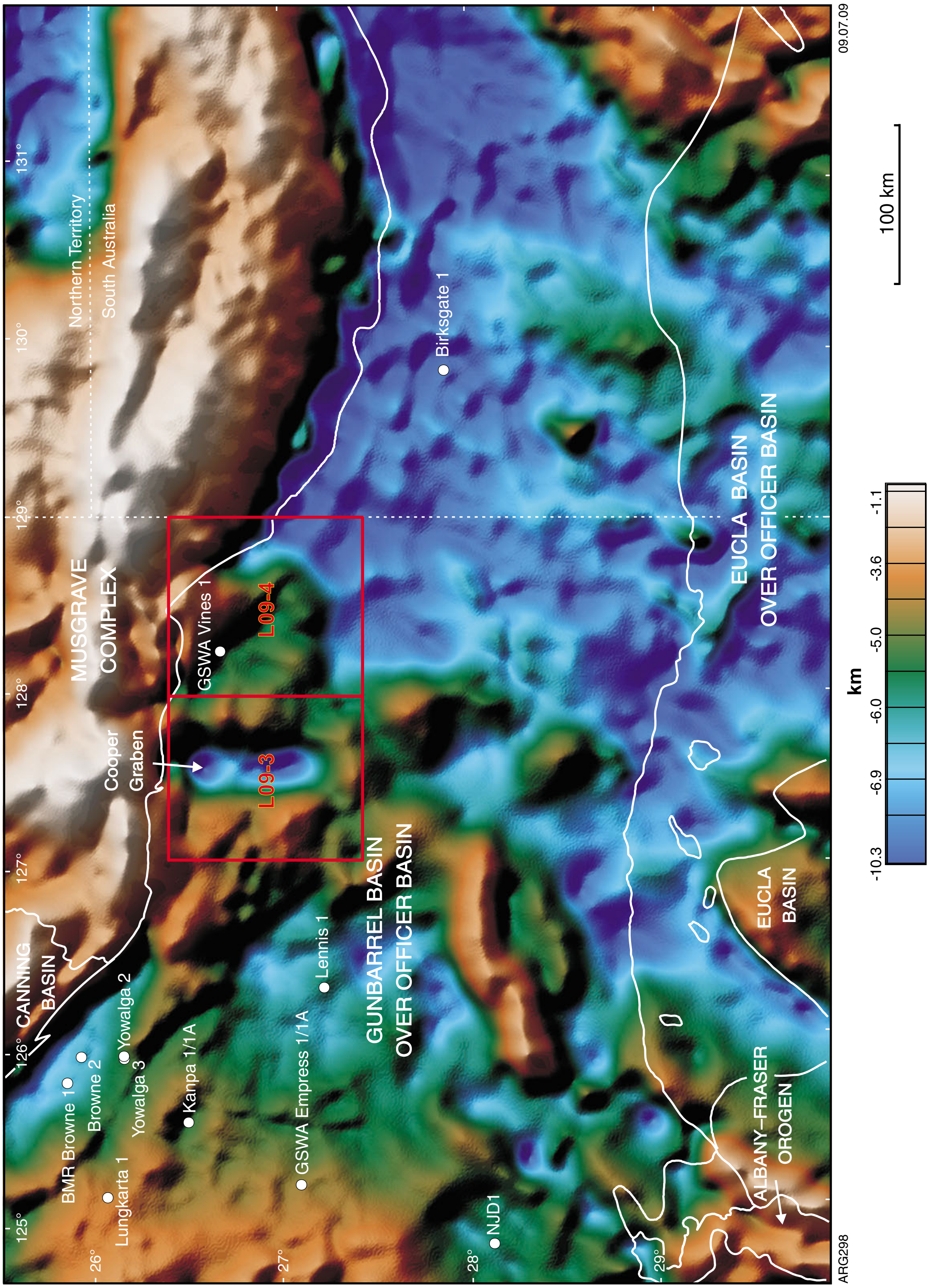

Figure 6. Depth to basement, modelled from gravity data, for the Waigen area and surrounds (after D'Ercole et al., 2005).

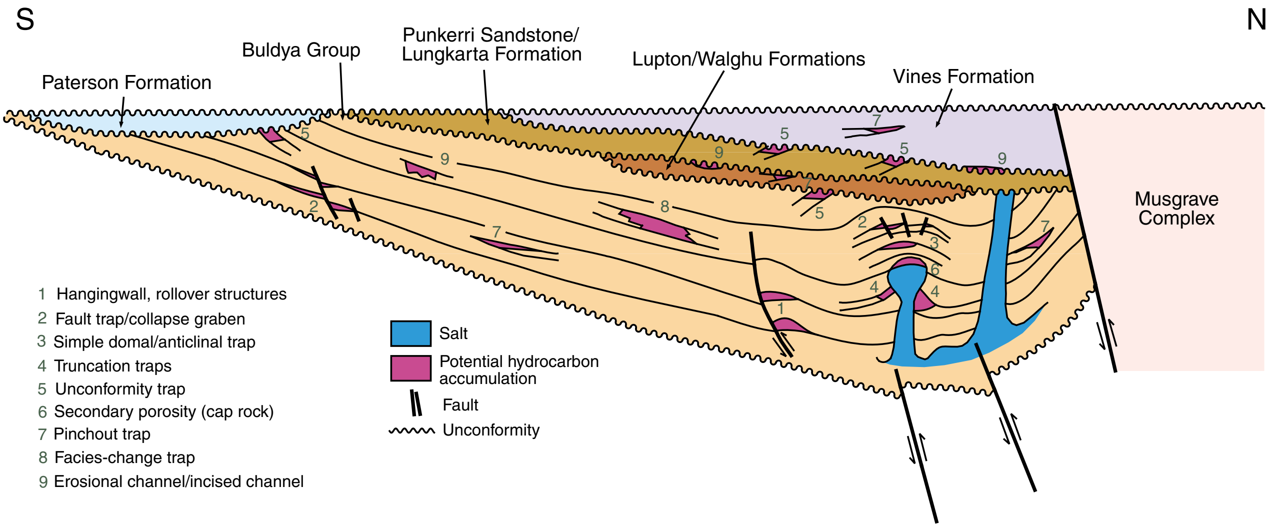

Figure 7. Schematic petroleum plays within the Waigen area (after D'Ercole et al., 2005).

the pores at these depths. These sandstones have excellent porosity (22.4 – 27.6%) and permeability (95–818 md), possibly because evaporite minerals occupied much of the intergranular porosity early during burial diagenesis, but were subsequently dissolved by alkaline brine associated with the bitumen forming process. The source of both the gas and bitumen is unclear as no source rocks were intersected in the drillhole, but thermal maturity is assessed as late-mature to overmature based on equivalent vitrinite reflectance of about 0.8% at 400 m and 1.15% near total depth. The revised interpretation of Vines 1 raises the possibility of salt-related plays at shallower depths than previously considered, and of plays based around interbedded massive sands and diamitites in the Pirrilyunka Formation (Haines et al., 2008).

The Waigen area appears to be continuous with the Birksgate Sub-basin of South Australia. D'Ercole et al. (2005) concluded from potential field data that up to 11 km of Neoproterozoic–Cambrian and possible underlying Mesoproterozoic strata are preserved, covered by a thin Phanerozoic section (Fig. 6). Numerous trap styles are possible (Fig. 7) and they concluded that although the prospectivity of this area is highly speculative, the shows in Vines 1 indicate that further investigation is warranted.

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Most of the references listed above are available on the Western Australia Petroleum Acreage Release, September 2009 CD as pdf files.

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